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ATOMIC RESEARCH

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1. Introduction

This report documents work performed by the University of Alabama in Huntsville's (UAH) Center for Applied Optics (CAO) under NASA contract number NAS8-38609 (delivery order number 32) entitled Atomic Research. Atomic oxygen (AO) effects on materials have long been a critical concern in designing spacecraft to withstand exposure to the Low Earth Orbit (LEO) environment. The objective of this research effort was to provide technical expertise in the design of instrumentation and experimental techniques for analyzing materials exposed to atomic oxygen in accelerated testing at NASA/MSFC. Such testing was required to answer fundamental questions concerning Space Station Freedom (SSF) candidate materials and materials exposed to atomic oxygen aboard the Long-Duration Exposure Facility (LDEF).

The primary UAH task was to provide technical design, review, and analysis to MSFC in the development of a state-of-the-art 5 eV atomic oxygen beam facility required to simulate the RAM-induced LEO AO environment. This development was to be accomplished primarily at NASA/MSFC. In support of this task, contamination effects and ultraviolet (UV) simulation testing was also to be carried out using NASA/MSFC facilities. Any materials analysis of LDEF samples was to be accomplished at UAH.

2. Advanced Atomic Oxygen Simulation System (AAOSS)

Following the start of this effort, a preliminary design for the AAOSS was received by the UAH team for evaluation. Comments and suggestions were then returned to NASA/MSFC personnel. Information regarding the material, design, and fabrication techniques for a portable, three-piece table to support the system was also provided. Following completion of the support table, work was begun on the fabrication and assembly of the AAOSS. Components worked on included the high-vacuum system, the pumping train, valves, electrical and mechanical feed-throughs, and annunciator/data acquisition equipment. The UAH team consulted with the NASA engineers and technicians throughout this phase to assure that the requirements were

met for valid space AO simulation. A partial list of components that were received, inspected, and installed is given in Table 1 below.

Target chamber	Pumping duct
Yoke supports	Plasma chamber
Coax exciter flanges	Side extension ports
Isolation valves	Pumping train
Turbo pump & controller	Plasma chamber extension
Passive measurement equipment	Backing & roughing pumps
Cooling block for neutralizer	Cooling/heating neutralizer plate
Baffle plate attachment ring	Gas choke face-plate
Inconel igniter & gas input flange	Coaxial plasma source flange
Re-entrant spectrometer flange	Spectrometer ion shielding flange
Gas choke tube	Baffle elements
Side port flange feed-through	Gas cylinder mounts & tubing

TABLE 1. AAOSS Components.

Once the water, air, and gas lines (with gauges) were installed, the vacuum system was started and checked for reliability. A pressure of 10^7 torr was achieved. This was acceptable for LEO space simulation testing and evaluating of materials. An important design feature was the use of a cooled neutralizer block to maintain the neutralizer plate within the required temperature range. Also, the magnet coils were arranged in a Hemholtz field configuration to confine the plasma. A hybrid plasma source was developed and a microwave magnetron was assembled to power the plasma source. A pressure-differential tube was designed and fabricated using only SS parts followed by electro-polishing for easy disassembly and cleaning. This component was required since the beam chamber was to operate at approximately 10^4 torr while the residual gas analyzer was to operate at 5×10^6 torr. Some re-design/re-work of the water pressure connectors was required for temperature control of the magnet coils.

Engineering expertise was provided by UAH for the development of a state-of-the-art neutral AO beam facility, including design, assembly, and checkout of system instrumentation. However, due to the lack of certain

required electrical and other utilities within the NASA/MSFC facility, the AAOSS was not fully operational at the conclusion of this effort. Thus, no sample testing was possible in the new system within the contractual period of performance.

3. Contamination Effects Testing of HYSOL 9313

The objective of this task was to investigate the contamination effects of HYSOL 9313 on candidate LEO materials in preparation for AO testing in the AAOSS. The *In-Situ* Contamination Effects Facility and the Automatic Contamination Evaluator at MSFC were to be utilized for this testing.

3.1 In-Situ Facility and the Automatic Contamination Evaluator (ACE)

Two preliminary tasks had to be accomplished prior to testing. First, the *In-Situ* facility had to be cleaned, made ready for full operation, and checked-out. Secondly, the ACE had to be incorporated into the *In-Situ* facility vacuum chamber. Unnecessary items were first removed from the vacuum chamber to insure enough room for the standard *In-Situ* instrumentation and the ACE. Next, the entire system was thoroughly cleaned. Finally, the operating procedures for both systems (UAH report & notebooks prepared by Ken Herren for the *In-Situ* facility and the operation manual supplied by Acton Research for the ACE) were studied and reviewed to insure performance and safety.

Much work was required for proper operation of the vacuum ultra-violet ACE instrument in the vacuum chamber. First, the platform that supported the original contamination system and optics had to be removed along with the coolant lines that attached to the sample mount. The coolant line feed-through flange was then replaced with a flat so that the system's vacuum capability could be evaluated. Utilizing the cryopump, the empty chamber reached a vacuum level of approximately 8.0×10^{-7} torr. All of the optical components that were removed previously were cleaned. All of the electrical connections were checked and repaired as necessary. The coolant lines and collimator were sent for lox cleaning.

The next stage consisted of preparing the ACE for use in the *In-Situ* facility. First, the ACE was removed from storage and set up for a test run outside of the vacuum chamber. This involved a search for various component parts of the ACE and a functionality test of each. The ACE had several components that had to be connected together for operation of the complete system. The main modules were the optical module, the electronics module, a high voltage power supply, and a computer system. Once the ACE was fully assembled on the lab bench, several practice runs were made. All controls were through the computer, but there are separate commands for operation of the ACE at atmospheric pressure and for operating it in a vacuum. It was determined at this time that only the optical module would actually be installed inside the vacuum chamber due to space limitations (the electronics module was, however, vacuum qualified). With this in mind, a support platform for the optics module was developed that would fit on top of the existing platform. It was also found that the ACE optics module would have to be cooled for proper operation in vacuum. Thus, a set of coolant lines that fed off the original lines was developed with a brass plate designed to be placed in contact with the module housing near the lamp/sample wheel area.

A contamination source separate from the standard source in the chamber was required for the ACE. A resistive heater was incorporated onto a contamination housing. This housing was made to sit on the platform that held the optics module and could be thermally isolated from the ACE unit itself. Installation of the ACE required that a new wire feed-through be installed on the chamber. This was done with a T-connector to which the appropriate feed-through had been connected. The connections to the inside of the chamber were made before the feed-through was connected to the T and were fed into the chamber as the T was connected. If there should ever be a problem with these connections, the entire T connector will have to be removed to adjust or correct them. It should be noted that two custom sets of wires exist for supplying power to the ACE lamp. One set (for operation through a feed-through) has BNC connectors on one end and custom ACE connectors on the other end while the other set (for operation on the bench or without a feed-through between the optics and electronics modules) has custom connectors on both ends. Both sets of wires should be kept with the ACE unit at all times as they are not standard and would be extremely hard to replace. The electronics module was installed in one of the equipment racks next to the chamber. The power supply and computer were placed on the lab

bench near the chamber. A power supply for the contaminant heater was placed underneath the chamber with two wires entering the chamber through another feed-through.

3.2 Problems with the *In-Situ* Facility and the ACE

Several problems were encountered during this time frame relating to the operation of the chamber and the test equipment. First, there was a problem with the ACE heating up in the vacuum chamber as long as it was turned on. It was decided to try and cool the ACE with the coolant lines, but this only proved marginally successful. Thus, the ACE had to be kept off as much as possible to prevent a serious heat build up. Further, the ACE UV lamp failed. After the first test, the ACE was unusable and arrangements were made to replace the lamp. Another problem involved the TQCM. The TQCM sensor sat above the primary mirror in the chamber. The sensor quit working during the second test. The sensor was replaced, but the replacement had a temperature control problem which significantly affected the validity of its data. The electronics component was replaced and a different control unit was used until a properly functioning unit was obtained for the third HYSOL test. The new TQCM was tested during a chamber check after the second test.

3.3 HYSOL 9313 Testing

HYSOL 9313 was tested utilizing both the ACE and the standard contamination test equipment that was in the *In-Situ* Facility. Three tests were performed on HYSOL from July to September of 1992.

3.3.1 Test One

This test was designed to be different than previous tests with the ACE collecting data along with the "regular" data. The objective of the test was to determine the effects of the HYSOL contamination on the optical properties of the witness samples as well as the effects of temperature and pressure on the contamination film. For this test, three witness samples were used in the ACE: a standard magnesium fluoride optical witness sample (OWS), a gold

mirror, and an iridium mirror. Another standard OWS was used in the standard *In-Situ* test position.

The procedure that was developed consisted of starting with the *In-Situ* contaminant at a temperature of 22° C. The non-ACE sample (OWS) was to be started at ambient temperature, then taken down to about 10° C, then to 0° C, and then as low as possible. This witness sample cool down procedure would then repeated with the contaminant at 33° C.

The actual test conditions were as follows. The initial HYSOL temperature was 23° C. The test sample was cooled to 10° C from 23.4° C at 4 hours into the test. The primary *In-Situ* test equipment was turned off at 49 hours into the test, leaving the ACE to be run. The initial ACE conditions indicated the samples at 28° C and the ACE HYSOL at 24° C. The ACE test samples had to be cooled slightly as the ACE optics module heated up. The test temperature conditions were then as follows:

<u>HOUR</u>	<u>HYSOL TEMP</u>
57	36 C
82	66 C
142	98 C
166	24 C

The final ACE data was taken at 166 hours.

At the end of the test, there was a distinct blue haze on the *In-Situ* witness sample. There was a noticeable, but light blue haze on the three ACE samples. From the ACE data, the conditions of the three ACE samples were found to be as follows: less than 3 percent decrease in reflectance on the magnesium fluoride sample; less than 5 percent decrease in reflectance on the gold mirror; up to 25 percent decrease in reflectance on the iridium mirror.

3.3.2 Test Two

The second test was performed utilizing only the primary *In-Situ* test equipment. The sample used was an iridium mirror. The initial conditions consisted of the HYSOL and the mirror at 21.9° C. The test temperature conditions were as follows:

<u>HOUR</u>	<u>MIRROR TEMP</u>	<u>HYSOL TEMP</u>
22	14° C	22° C
26	14° C	33° C
50	10° C	33° C
60	10° C	26° C
75	22° C	22° C

Final data was taken at 75 hours.

A maximum of 38 percent decrease in reflectance was seen at about 55 hours into the test. However, the data seemed to show about a 20 percent decrease at the end of the test. When the mirror was retrieved from the chamber, there was a slight blue haze on it. The TQCM data showed a net mass loss during the test. However, this data was found to be erroneous as the TQCM was not working properly.

3.3.3 Test Three

The third test was also performed using only the primary *In-Situ* test equipment. A magnesium fluoride sample was used for this test. The initial conditions of the test consisted of the sample and HYSOL temperatures at 22° C. The test temperature conditions were as follows:

<u>HOUR</u>	<u>MIRROR TEMP</u>	<u>HYSOL TEMP</u>
6	10° C	32° C
80	10° C	37° C
165	10° C	37° C

Final data was taken at hour 165.

At no time during the test was there a significant change in the reflectance of the magnesium fluoride. There was a small mass increase noted by the TQCM. At the end of the test, the sample was found to be very slightly cloudy.

3.4 Results and Conclusions for HYSOL 9313 Testing

The results of the HYSOL testing appear clear. According to this data, HYSOL is a potentially significant contaminant to some optical components. Magnesium fluoride contamination was slight and the only change in reflectance observed in the VUV was fairly small. The VUV reflectance degradation was also relatively small for the gold mirror. However, the iridium mirror's optical properties in the VUV were drastically altered. More samples should be tested and the synergistic effects of AO exposure should be studied in the future.

With a replacement bulb, the ACE system should be a good addition to the *In-Situ* Contamination Effects Facility. It can provide very useful data, but a new system of cooling the optics module needs to be found to provide adequate temperature control. The *In-Situ* Contamination Effects Facility is still a valuable source of data in the investigation of VUV optical changes induced by contamination.

Further details regarding system operation and the testing performed on HYSOL 9313 can be found in the MSFC Laboratory Notebooks labeled "*In-Situ* Contamination - System Notebook" and "*In-Situ* Contamination - Test Notebook" prepared by Rob Connatser. These notebooks were left with Roger Linton of NASA/MSFC (EH-12).

4. UV Exposure Testing of Contaminated Windows

After several months, the UV lamp in the ACE was replaced, allowing further testing with the unit inside the *In-Situ* vacuum chamber. The purpose

of this testing was to investigate the VUV transmission properties of contaminated windows as a function of solar-UV exposure. The window samples had been previously contaminated for MSFC at Princeton University. They consisted of various magnesium fluoride, calcium fluoride, and lithium fluoride windows. It was decided to perform this testing prior to any AO exposure testing in the new AAOSS system.

4.1 In-Situ Facility and ACE Check-Out

During the break between the HYSOL testing and this UV exposure testing, the turbo pump on the vacuum chamber had been removed. Thus, the oil diffusion pump was reconnected, through a cold trap, directly to the chamber for roughing. Also, the ionization vacuum gauge filament was burnt out and had to be replaced. For these tests, the contamination source used with the ACE was not required and was removed. Instead, a compact VUV source was required to expose the ACE samples inside the chamber. The source was a small diameter krypton resonance lamp with a MgF_2 window (peak emission at 123.6 nm). Use of the standard *In-Situ* krypton source would have required major changes to the inside of the chamber. Therefore, a small VUV lamp (previously used by MSFC personnel for other testing) was to be used. This required only that two power supply lines be available inside the chamber to run the lamp. The wires previously used to supply current to the resistive contaminant heater were utilized for this purpose. On the outside of the chamber, the corresponding wire leads were removed from the heater control and attached to the lamp power supply. Leads were then soldered to the lamp which was placed in the teflon holder fabricated previously for such lamps. During testing, the lamp could then be placed directly on top of the ACE optics module (facing the exposed samples) and the soldered leads attached to the wires from the feed-through to the power supply. A black shroud was to be placed over the chamber window to prevent inadvertent exposure of lab personnel to the UV radiation.

Next, the ACE unit, which had been removed from the chamber for storage, was inspected and cleaned. Five samples were then placed in the ACE sample wheel. They consisted of two mirrors (gold & aluminum w/ MgF_2) as references and three contaminated windows. The sample placement

and ID numbers were as follows:

<u>SAMPLE</u>	<u>ID#</u>	<u>SAMPLE WHEEL LOCATION</u>
Open	N/A	0
Al/MgF ₂	20-92	I
UV Window	PR13	II
UV Window	PR9	III
UV Window	PR11	III
Au	AU1-92	IIII

This placement put the three windows in the exposed positions on the ACE (positions 0, 1, & 5 were inside the ACE housing when not measuring). It was believed that all three of the windows were magnesium fluoride, but this was not verified at the time (they can be checked if required using their ID numbers).

It was decided to run an ACE checkout on the lab bench prior to re-installing the unit inside the vacuum chamber. The ACE was connected and powered up on the bench, and then initialized using the "228 LOAD OUTSIDE" command (sets system for non-vacuum operation at 210 nm). A run was then made using the Rapid Data (5 samples) scan. Without any other commands, only reflectance values were measured for all five samples; transmission values were required for the three test windows. After some time and several calls to Bob Jarrett at Acton Research, the proper method for setting the reflectance/transmission for each sample was discovered (it was not contained in the ACE operating manual). First, the hex value of an 8-bit byte with the following structure had to be determined:

0 0 S5 S4 S3 S2 S1 1.

The first two bits were found always to be zeros. The following five bits represented each sample position (S5 down to S1). A sample bit was found to be a 0 if reflectance was to be measured and a 1 if transmission was to be measured. The last bit was always 1. For this case, S1 & S5 - reflectance and S2, S3, & S4 - transmission, the byte would have the following form:

0 0 0 1 1 1 0 1.

This binary value then had to be converted to hex (using a table or pocket calculator). The hex value in this case was found to be 1D. Using the command mode from the second software menu, the command

HEX XX (MODE) C! DECIMAL

had to be entered where XX represents the hex value obtained above (1D in this case). This command was then hand-written into Appendix F of the ACE manual.

The bench test was then repeated using the HEX 1D (MODE) C! DECIMAL command. The unit ran smoothly with the correct reflectance/transmission measurements made. The results, at 210 nm, appeared normal (Al/MgF₂ R = 82%, Au R = 19%, window T's = 81-83%). The data was stored as ACE Rapid Data 5 record number 450. A hardcopy of this record is included in Appendix A of this report.

Next, the ACE optics module was placed in the *In-Situ* vacuum chamber using the platform and electrical feed-throughs previously assembled for it. The coolant lines were placed up against the unit. The main power cable from the electronics module attached to the face of the T connector on the chamber. The ACE deuterium lamp power supply cables connected to the color-coded BNC connectors on the bottom of the T. The UV exposure lamp was connected and placed on top of the ACE module approximately 5 cm from the samples. The chiller unit set-point was set at 5° C. The chamber was then closed and pumped-down using the following procedure:

1. Insure chamber is securely closed and all valves and vents to atmosphere are closed.
2. Check that cryo-pump gate valve is closed (not plugged in) and roughing pump is off (switch in down position).
3. Hook up LN₂ to EH-12 controller valve. Open LN₂ tank valve.
4. Press "Start" button on EH-12 to initiate LN₂ flow into cold trap. If trap overflows, close off LN₂ at tank valve until EH-12 valve closes (light on controller will go off). Then re-open tank valve. EH-12 will now refill cold-trap at regular intervals.
5. Turn on roughing pump and open valve between cold trap & chamber.

6. Monitor Varian 801 TC vacuum gauge (normally always on) for pumping progress. When gauge reads between 10 & 30 millitorr, system is ready for cryo pumping (normally about 15 minutes).
7. When TC gauge reads below 30 millitorr, turn on Varian 860 cold cathode vacuum gauge. Should read in 10^3 to 10^4 torr range.
8. Close roughing pump valve (between cold trap & chamber) and turn roughing pump off. Turn EH-12 off (hit "Stop" button on controller) and close LN₂ tank valve.
9. Check that cryo pump is on and operating properly (temperature gauge needle inside blue range). Open gate valve between cryo pump & chamber by plugging it in. Re-check that temperature is OK.
10. Monitor cold cathode gauge for pumping progress. When gauge reads in 10^4 torr range or lower, switch to the Granville-Phillips ionization vacuum gauge for more accurate measurements. The actual gauge is on top of the chamber, but the controller is in the left-hand electronics rack next to the chamber. Turn on the controller, check DE-GAS off, and AUTORANGE on. Then turn filament on (switch up). The light next to the switch will come on to indicate the filament is operating properly. The value on this gauge is usually about 10 times lower than the cold cathode gauge due to their different locations in the vacuum system. When not monitoring the vacuum level, the ionization gauge filament should be turned off to avoid premature failure.
11. After 24 hours of cryo pumping, the chamber should at least be in the low 10^6 torr range. If it is not, check for leaks and/or other problems.

After 24 hours, the chamber was at 1.2×10^6 torr. The ACE was powered up and initialized for vacuum operation. The unit was first checked for proper operation prior to UV exposure. The command was given to yield reflectance measurements on the mirrors (samples 1 & 5) and transmission measurements on the windows (samples 2, 3, & 4). Initial ACE temperatures were 25°, 25°, 27°, & 26° C for the sample housing, grating base, D₂ lamp housing, and electronics module, respectively. An Acquire Standard Data run was then made (making ten measurements on each sample from 121.6 to 210.0 nm). The temperatures after the scan were 27°, 27°, 28°, & 26° C. Thus, there was a definite temperature rise within the optics module inside the chamber. The

unit ran smoothly with the correct reflectance/transmission measurements made. The results appeared normal (Al/MgF₂ R = 70-88%, Au R = 8-18%, window T's = 42-84%). The data was stored as ACE Standard Data record number 74. A hardcopy of this record is also included in Appendix A.

This completed the check-out of the *In-Situ* Facility and the ACE unit as required for UV exposure testing. The heating seen in the ACE optics module was seen as a potential problem during testing. However, it was decided to proceed with the test with the chiller unit running at an even lower setting than previously used and to power down the ACE between measurements.

4.2 UV Exposure Testing

This UV exposure test was made on April 22, 1993. The goal of the test was to document any changes in transmission of the windows in the 120 to 210 nm wavelength range during a 10 hour exposure to the krypton lamp at 5 cm distance. The lamp was to be operated at half-scale on the power supply (this was where the lamp had been calibrated relative to equivalent sun hours).

The lamp was turned on and set to 50% power at 8:45 AM. Operation was confirmed by observing a bluish glow from the lamp while wearing UV safety glasses. Due to the mostly collimated beam from the lamp and a lack of a mechanism to constantly scan the ACE sample wheel, the center sample (window PR9 in sample position 3) bore most of the exposure. Measurement scans were taken at regular intervals throughout the exposure (nominally every 30 minutes). Table 2 gives a record of the test sequence. In the table, the ACE temperatures given are for the sample housing, the grating base, the D₂ lamp housing, and the electronics module, respectively. The ACE record numbers are given and hardcopies are included in Appendix A. On the hardcopies, the average reflectance or transmission value is given for most samples as a check on measurement repeatability and trends. The variation from the first vacuum scan (record #74) is also noted on the hardcopies.

As can be seen from the table, the temperature of the ACE optics module was extremely hard to control. The combination of cooling the unit with the two chiller lines and shutting down the unit between measurements was

LOCAL TIME	UV EXPOSURE (at calibrated 1.5 mA level)	TEMPS (°C)	ACE RECORD #	COMMENTS
8:30	None	27,27,28,26	74	Pre-UV measurment, chiller at 5° C.
8:45	00 min	27,28,29,27	N/A	Exposure lamp started at 1/2 scale (actual current of 0.50 mA).
9:07	07 min	31,30,32,29	75	1st UV meas, vacuum OK.
9:30	15 min	31,32,33,30	76	Noticing problem with Au values (0's).
10:03	26 min	34,32,36,31	77	Au better, vac OK.
11:00	45 min	37,37,39,32	78	Chiller set at -10° C, Au problem again.
11:30	55 min	40,37,42,32	79	Temps going up rapidly.
12:00	1 hr 05 min	41,40,43,32	80	Au still has bad data points.
13:05	1 hr 27 min	45,44,46,33	81	Data OK, vac still good, temps up.
13:38	N/A	46,48,48,34	N/A	Temp check - not under control.
14:00	1 hr 45 min	45,48,50,35	454	Rapid Data scan at 121.6 nm, Au bad.
14:05	1 hr 47 min	46,47,49,34	82	Good data.
14:39	N/A	48,49,51,34	N/A	Temp check - getting too high.
14:45	N/A	N/A	N/A	ACE shut-down for cooling.
15:05	N/A	48,48,49,32	N/A	Temp check - coming down very slowly.
15:45	2 hr 20 min	N/A	N/A	Thought had 7 hrs, set 2 mA on lamp.
15:55	N/A	46,46,46,29	N/A	Temp check - still slow to cool.
16:00	2 hr 40 min	45,46,44,29	83	Re-start, vac OK.
16:35	N/A	47,46,50,30	N/A	Temp check - back up quickly.
16:36	N/A	N/A	N/A	ACE shut-down for cooling.
17:06	N/A	45,45,46,29	N/A	Temp check - going down.
17:30	4 hr 40 min	45,45,46,29	84	Re-start, still bad Au data.
18:00	5 hr 20 min	48,48,49,31	85	All data looking suspicious now.
18:36	N/A	48,46,52,32	N/A	Temp check - very high.
18:45	6 hr 20 min	46,46,50,32	86	Data irregular., vac OK.
19:00	6 hr 40 min	49,49,50,32	87	Last meas of test.

TABLE 2. UV Exposure Testing Record.

not very successful. In addition, the ACE lamp was apparently still having the same problems that led to its failure previously. As the test progressed, the the number of anomolous data values drastically increased (such as 0.00% and/or >100% T or R readings). It was noted that the ACE lamp anode voltage increased from 232 V to 294 V while the anode current decreased from 44 mA to 32 mA over the course of the test.

Another problem concerned amount of UV exposure. At approximately 3:45 PM (7 hours into the 10-hour test), it was discovered that the exposure lamp power supply that had been given to the UAH investigator by the MSFC staff was not the same one that had been used for the calibration relative toequivalent sun hours. The power supply used had a range of 0 to 1.0 milliamps while the power supply used during calibration ranged from 0 to 3.0 milliamps. Thus, exposure at 50% power, as used up to this point in the test, yielded 0.5 milliamps rather than 1.5 milliamps (50% power on calibration supply). In other words, the effective exposure time, at the calibrated level, was 1/3rd of the actual time of 7 hours, or 2.3 hours. At this point, the calibration power supply was obtained and connected to the lamp. However, even running at the maximum output power of 2 milliamps (would not reach full-scale value of 3 milliamps), 5.75 hours would have been required to reach an effective exposure of 10 hours at the original 50% level of 1.5 milliamps. Due to the overheating problems and operator limitations, this was not possible. The test was continued at the accelerated exposure level (1.3 times design rate) until 7:00 PM for an effective exposure of 6.67 hours. It was decided to re-run the test the following week using the desired power supply current of 1.5 milliamps. At this point, the ACE and the UV exposure lamp were shut down, the cryo pump was closed off, and the chiller was turned off until the next test.

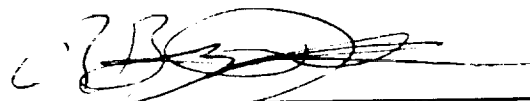
The following week, the chamber pressure had risen to 320 millitorr. It was decided to run a measurement on the ACE prior to cryo pumping. The ACE was powered-up in the chamber and initialized for atmospheric measurments (due to the low level of vacuum). The chiller was turned on and set to -10° C. A Rapid Data 5 scan was made (record #456, Appx. A) at 210 nm. The resulting data were extremely bad. The values were not as to be expected, they were not even similar to the previous atmospheric values, and they were not at all consistent (some values >100%). The ACE temperatures were 24°, 23°, 24°, & 23° C. Further scans also resulted in bad data. The

chamber was then vented and another scan made. Reliable data could still not be obtained. At this point, the ACE lamp anode voltage was up to 304 V while the anode current was down to 22 mA. Bob Jarrett was then contacted at Acton Research. He thought, based on the fact that this was very similar to what happened prior to the first lamp failure, that the ACE D₂ lamp power supply (located in the electronics module outside the chamber) was malfunctioning and causing premature degradation in lamp performance. He was not sure if the high temperatures seen in the optics module were a factor (the stated limit of operation was 70° C). It was determined that the ACE unit would require major repair before reliable data could be obtained again. For this reason, the desired second UV exposure test could not be accomplished under this contractual effort. It will have a high priority in any follow-on work. The ACE optics module and the UV exposure lamp were removed from the vacuum chamber and the electronics module was moved back to the lab bench next to the computer. The vacuum chamber was closed off (cryo pumping on itself).


4.3 Results and Conclusions for UV Exposure Testing

During this UV exposure run, no significant degradation in the transmission characteristics of the contaminated windows was observed in the 121.6 to 210.0 nm wavelength region. If the ACE unit can be effectively repaired and a better cooling mechanism developed, it still should prove to be a simple and valuable tool in investigating VUV properties of optical materials exposed to various LEO environments.

Further details regarding this testing can be found in the MSFC Laboratory Notebook labeled "UV Exposure Testing using ACE in *In-Situ* Facility Chamber" prepared by James Hadaway. This notebook was left with Roger Linton of NASA/MSFC (EH-12).



R. Barry Johnson
Principal Investigator



Date

APPENDIX A

ACE Measurment Results for UV Exposure Testing

PRE-TEST

Record # 450 (At atmosphere)

SYSTEM STATUS 15 APR 1993 015:42:10

FNT VOLTAGE = 3707 VOLTS
 +28 SUPPLY VOLTAGE = 27.2 VOLTS
 +12 SUPPLY VOLTAGE = 12.0 VOLTS
 SAMPLE HOUSING TEMP = 26 C
 GRATING BASE TEMP = 25 C
 FILAMENT VOLTAGE = 5.1 VOLTS
 ANODE CURRENT = 104 ma
 CHECKSUM = 59205 DARK READING = 0

FNT SUPPLY VOLTAGE = 28.3 VOLTS
 +5 SUPPLY VOLTAGE = 5.0 VOLTS
 -12 SUPPLY VOLTAGE = 12.0 VOLTS
 D2 LAMP HOUSING TEMP = 26 C
 ELECT. MODULE TEMP = 26 C
 ANODE VOLTAGE = 200 VOLTS

RM	S1	S2	S3	S4	S5
210.00	082.3%R	082.5%T	081.0%T	083.0%T	019.7%R
	081.9%R	081.9%T	080.8%T	082.6%T	019.2%R
	081.3%R	081.3%T	079.6%T	083.2%T	019.3%R
	082.6%R	082.2%T	080.8%T	083.8%T	019.4%R
	082.4%R	082.7%T	081.1%T	083.2%T	019.0%R
	081.8%R	082.5%T	081.0%T	083.2%T	019.9%R
	081.5%R	082.2%T	080.3%T	083.5%T	019.0%R
	082.2%R	081.8%T	081.0%T	083.0%T	019.7%R
	082.7%R	082.4%T	081.5%T	083.8%T	019.4%R
Avg.	82.1%R	82.2%T	80.8%T	83.3%T	19.4%R
	Al/MgF ₂	Window PR13	Window PR9	Window PR11	Al

ORIGINAL PAGE IS
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Record # 74 (In vacuum)

SYSTEM STATUS 22 APR 1993 008:15:53

PMT VOLTAGE = 3707 VOLTS

+28 SUPPLY VOLTAGE = 27.0 VOLTS

+12 SUPPLY VOLTAGE = 12.0 VOLTS

SAMPLE HOUSING TEMP = 27 C

GRATING BASE TEMP = 27 C

FILAMENT VOLTAGE = 5.4 VOLTS

ANODE CURRENT = 44 ma

CHECKSUM = 1243 DARK READING = 0

PMT SUPPLY VOLTAGE = 28.3 VOLTS

+5 SUPPLY VOLTAGE = 5.0 VOLTS

-12 SUPPLY VOLTAGE = 12.0 VOLTS

02 LAMP HOUSING TEMP = 28 C

ELECT. MODULE TEMP = 26 C

ANODE VOLTAGE = 232 VOLTS

NH	S1	S2	S3	S4	S5
121.00	074.7%R	049.5%T	041.5%T	047.8%T	010.7%R
125.00	077.0%R	053.4%T	045.0%T	050.0%T	009.6%R
130.00	075.0%R	055.8%T	052.4%T	055.8%T	007.5%R
144.00	069.7%R	067.4%T	063.2%T	066.9%T	012.0%R
150.00	073.1%R	071.1%T	063.0%T	068.2%T	014.2%R
161.00	069.9%R	073.4%T	069.9%T	072.4%T	014.3%R
170.00	071.6%R	080.6%T	069.0%T	078.7%T	014.1%R
180.00	074.0%R	083.9%T	068.5%T	072.2%T	013.5%R
190.00	072.1%R	076.9%T	060.3%T	055.0%T	008.2%R
210.00	087.5%R	076.5%T	052.4%T	064.1%T	017.9%R

Ag.	74.5 %R	68.9 %T	58.5 %T	63.1 %T	12.2 %R
	Al/M ₂ F ₂	PR13	PR9	PR11	Au

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OF POOR QUALITY

Record # 75

SYSTEM STATUS 22 APR 1993 009:06:24

PMT VOLTAGE = 3706 VOLTS
+25 SUPPLY VOLTAGE = 27.0 VOLTS
+12 SUPPLY VOLTAGE = 12.0 VOLTS
SAMPLE HOUSING TEMP = 31 C
GRATING BASE TEMP = 30 C
FILAMENT VOLTAGE = 5.3 VOLTS
ANODE CURRENT = 40 ma
CHECKSUM = 45203 DARK READING = 0

PMT SUPPLY VOLTAGE = 28.3 VOLTS
+5 SUPPLY VOLTAGE = 5.0 VOLTS
-12 SUPPLY VOLTAGE = 12.0 VOLTS
D2 LAMP HOUSING TEMP = 32 C
ELECT. MODULE TEMP = 29 C
ANODE VOLTAGE = 242 VOLTS

NM	S1	S2	S3	S4	S5
121.60	073.3%R	047.9%T	038.5%T	047.1%T	009.4%R
125.00	074.4%R	053.2%T	047.0%T	031.2%T	009.8%R
130.00	041.1%R	073.0%T	058.8%T	034.9%T	000.0%R*
144.00	070.4%R	070.4%T	061.3%T	065.9%T	015.9%R
150.00	067.2%R	070.0%T	061.6%T	066.3%T	009.3%R
161.00	068.3%R	074.0%T	066.2%T	070.9%T	013.8%R
170.00	070.0%R	078.3%T	081.6%T	078.3%T	023.3%R
180.00	072.3%R	080.0%T	069.2%T	075.3%T	000.0%R*
190.00	078.7%R	077.2%T	077.2%T	077.2%T	000.0%R*
210.00	081.6%R	081.6%T	080.0%T	085.0%T	000.0%R*

69.7 -x3

64.1 +5.6

13.6 +1.4

↑

Difference
from first
measurement
(record # 74).

* Unreliable data
not included
in average

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 76

SYSTEM STATUS 22 APR 1993 009:27:21

PMT VOLTAGE	=	3710 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.0 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	31 C	Q2 LAMP HOUSING TEMP	=	33 C
GRATING BASE TEMP	=	32 C	ELECT. MODULE TEMP	=	30 C
FILAMENT VOLTAGE	=	5.2 VOLTS	ANODE VOLTAGE	=	256 VOLTS
ANODE CURRENT	=	52 ma			
CHECKSUM	=	38751	DARK READING	=	0

NP	S1	S2	S3	S4	S5
121.60	075.4%R	047.2%T	037.3%T	044.9%T	009.3%R
125.00	076.6%R	052.1%T	043.6%T	048.7%T	009.8%R
130.00	079.9%R	057.0%T	026.1%T	026.6%T	010.2%R
144.00	075.5%R	048.6%T	057.7%T	060.5%T	012.2%R
150.00	069.7%R	074.0%T	052.8%T	076.9%T	011.5%R
161.00	065.3%R	078.8%T	050.5%T	073.7%T	014.2%R
170.00	095.5%R	098.2%T	095.5%T	087.5%T	000.0%R ✖
180.00	067.7%R	072.5%T	072.5%T	079.0%T	000.0%R ✖
190.00	062.6%R	079.1%T	076.1%T	076.1%T	000.0%R ✖
210.00	088.3%R	081.6%T	070.0%T	081.6%T	000.0%R ✖
	75.7 +1.2		50.2 -1.3		11.2 -1.0

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 77

SYSTEM STATUS 22 APR 1993 010:03:39

PMT VOLTAGE = 3709 VOLTS

+28 SUPPLY VOLTAGE = 27.2 VOLTS

+12 SUPPLY VOLTAGE = 12.0 VOLTS

SAMPLE HOUSING TEMP = 34 C

GRATING BASE TEMP = 32 C

FILAMENT VOLTAGE = 5.3 VOLTS

ANODE CURRENT = 40 ma

CHECKSUM = 12586 DARK READING = 0

PMT SUPPLY VOLTAGE = 28.3 VOLTS

+5 SUPPLY VOLTAGE = 5.0 VOLTS

-12 SUPPLY VOLTAGE = 12.0 VOLTS

D2 LAMP HOUSING TEMP = 34 C

ELECT. MODULE TEMP = 31 C

ANODE VOLTAGE = 256 VOLTS

NM	S1	S2	S3	S4	S5
121.60	074.1%R	046.8%T	038.6%T	043.9%T	009.4%R
125.00	075.5%R	052.3%T	043.8%T	046.6%T	009.0%R
130.00	074.5%R	053.3%T	049.5%T	055.8%T	010.0%R
144.00	072.9%R	068.1%T	058.9%T	066.4%T	005.4%R
150.00	072.1%R	070.1%T	066.8%T	073.0%T	013.4%R
161.00	069.4%R	073.5%T	072.1%T	067.6%T	014.5%R
170.00	068.8%R	076.2%T	065.9%T	076.2%T	012.5%R
180.00	074.4%R	078.6%T	065.5%T	070.3%T	013.7%R
190.00	095.5%R	108.0%T	091.9%T	093.7%T	012.5%R
210.00	091.3%R	072.4%T	081.0%T	081.0%T	029.3%R
	76.9 +2.4		63.4 +7.1		17.0 +.8

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 78

SYSTEM STATUS 22 APR 1993 010:59:06

PMT VOLTAGE	=	3703 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.0 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	37 C	D2 LAMP HOUSING TEMP	=	39 C
GRATING BASE TEMP	=	37 C	ELECT. MODULE TEMP	=	32 C
FILAMENT VOLTAGE	=	5.4 VOLTS	ANODE VOLTAGE	=	272 VOLTS
ANODE CURRENT	=	44 ma			
CHECKSUM	=	15441	DARK READING	=	0

NM	S1	S2	S3	S4	S5
121.60	081.1%R	046.3%T	038.8%T	044.9%T	008.6%R
125.00	076.4%R	051.5%T	042.5%T	048.9%T	007.6%R
130.00	077.0%R	056.9%T	051.6%T	051.2%T	008.1%R
144.00	071.3%R	068.0%T	063.8%T	063.2%T	010.6%R
150.00	077.6%R	073.4%T	064.0%T	073.4%T	010.4%R
161.00	074.7%R	079.4%T	078.5%T	078.9%T	015.4%R
170.00	061.9%R	069.8%T	079.3%T	073.0%T	000.0%R ←
180.00	066.6%R	077.7%T	077.7%T	079.3%T	015.8%R
190.00	068.8%R	083.6%T	077.0%T	085.2%T	000.0%R →
210.00	068.8%R	072.1%T	077.0%T	068.8%T	027.8%R
	72.5 -2		65.0 +6.5		13.0 +.9

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 79

SYSTEM STATUS 22 APR 1993 011:29:41

PMT VOLTAGE	=	3703 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.2 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	40 C	D2 LAMP HOUSING TEMP	=	42 C
GRATING BASE TEMP	=	37 C	ELECT. MODULE TEMP	=	32 C
FILAMENT VOLTAGE	=	5.4 VOLTS	ANODE VOLTAGE	=	280 VOLTS
ANODE CURRENT	=	36 ma			
CHECKSUM	=	32994	DARK READING	=	0

NM	S1	S2	S3	S4	S5
121.60	053.8%R	025.7%T	032.5%T	041.1%T	010.3%R
125.00	078.4%R	053.0%T	044.5%T	049.8%T	008.8%R
130.00	074.0%R	056.9%T	050.4%T	058.3%T	011.1%R
144.00	073.2%R	068.7%T	063.0%T	062.5%T	007.9%R
150.00	092.7%R	048.9%T	045.2%T	050.3%T	010.2%R
161.00	065.8%R	070.9%T	067.2%T	072.8%T	015.2%R
170.00	071.1%R	077.9%T	071.1%T	089.8%T	06.9%R
180.00	065.0%R	079.3%T	080.9%T	073.0%T	000.0%R ✖
190.00	075.8%R	087.0%T	080.6%T	079.0%T	000.0%R ✖
210.00	082.4%R	082.4%T	089.4%T	084.2%T	035.0%R
	73.2 - 13		62.5 + 4		13.2 + 1

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 80

SYSTEM STATUS 22 APR 1993 011:59:53

PMT VOLTAGE	=	3704 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.2 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	41 C	D2 LAMP HOUSING TEMP	=	43 C
GRATING BASE TEMP	=	40 C	ELECT. MODULE TEMP	=	32 C
FILAMENT VOLTAGE	=	5.3 VOLTS	ANODE VOLTAGE	=	280 VOLTS
ANODE CURRENT	=	36 ma			
CHECKSUM	=	53404	DARK READING	=	0

NH	S1	S2	S3	S4	S5
121.60	060.3%R	034.6%T	027.8%T	031.7%T	007.8%R
125.00	075.8%R	051.1%T	041.9%T	048.2%T	012.6%R
130.00	072.5%R	054.8%T	051.3%T	055.7%T	008.8%R
144.00	066.6%R	066.6%T	060.6%T	063.6%T	000.0%R *
150.00	066.3%R	067.2%T	073.2%T	065.5%T	000.0%R *
161.00	071.9%R	079.0%T	073.1%T	079.0%T	016.2%R
170.00	069.6%R	084.8%T	074.2%T	086.3%T	015.1%R
180.00	076.1%R	073.0%T	077.7%T	079.3%T	015.8%R
190.00	071.2%R	071.2%T	084.8%T	080.3%T	021.2%R
210.00	074.5%R	083.6%T	076.3%T	087.2%T	000.0%R *

70.5 -4

64.1 +5.6

15.9 +1.7

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 81

SYSTEM STATUS 22 APR 1993 013:04:20

PMT VOLTAGE = 3498 VOLTS

+28 SUPPLY VOLTAGE = 27.2 VOLTS

+12 SUPPLY VOLTAGE = 12.0 VOLTS

SAMPLE HOUSING TEMP = 45 C

GRATING BASE TEMP = 44 C

FILAMENT VOLTAGE = 5.4 VOLTS

ANODE CURRENT = 32 ma

CHECKSUM = 61390 DARK READING = 1

PMT SUPPLY VOLTAGE = 28.3 VOLTS

+5 SUPPLY VOLTAGE = 5.0 VOLTS

-12 SUPPLY VOLTAGE = 12.0 VOLTS

D2 LAMP HOUSING TEMP = 46 C

ELECT. MODULE TEMP = 33 C

ANODE VOLTAGE = 286 VOLTS

NM	S1	S2	S3	S4	S5
121.60	075.1%R	046.0%T	035.4%T	042.8%T	008.9%R
125.00	073.7%R	048.9%T	048.9%T	048.2%T	011.7%R
130.00	064.0%R	053.9%T	050.5%T	050.5%T	000.0%R*
144.00	068.4%R	063.1%T	057.8%T	075.0%T	018.4%R
150.00	070.9%R	070.9%T	068.8%T	073.1%T	018.2%R
161.00	074.0%R	081.2%T	076.4%T	078.8%T	014.4%R
170.00	074.5%R	080.0%T	076.3%T	092.7%T	018.1%R
180.00	071.9%R	080.7%T	073.6%T	082.4%T	017.5%R
190.00	066.1%R	083.0%T	083.0%T	084.7%T	016.9%R
210.00	080.0%R	081.8%T	076.3%T	090.9%T	018.1%R

71.9 - 26

64.7 + 6.2

15.8 + 3.6

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 484

SYSTEM STATUS 22 APR 1993 013:59:35

FMT VOLTAGE = 3699 VOLTS

+25 SUPPLY VOLTAGE = 27.3 VOLTS

+12 SUPPLY VOLTAGE = 12.0 VOLTS

SAMPLE HOUSING TEMP = 25 C

GRATING BASE TEMP = 48 C

FILAMENT VOLTAGE = 5.4 VOLTS

ANODE CURRENT = 38 ma

CHECKSUM = 52386 DARK READING = 3

PHI SUPPLY VOLTAGE = 28.3 VOLTS

+3 SUPPLY VOLTAGE = 5.0 VOLTS

-12 SUPPLY VOLTAGE = 12.0 VOLTS

D2 LAMP HOUSING TEMP = 50 C

ELECT. MODULE TEMP = 33 C

ANODE VOLTAGE = 282 VOLTS

NP	S1	S2	S3	S4	S5
121.60	077.1%R	046.6%T	036.9%T	047.1%T	001.6%R
	081.5%R	046.0%T	039.0%T	052.1%T	010.4%R
	069.4%R	043.5%T	035.0%T	042.9%T	011.2%R
	073.6%R	047.9%T	036.2%T	041.5%T	000.0%R
	078.1%R	050.8%T	039.0%T	045.5%T	011.8%R
	079.2%R	046.0%T	040.4%T	046.0%T	000.0%R
	067.7%R	043.5%T	031.1%T	040.8%T	000.0%R
	077.7%R	050.2%T	032.5%T	049.7%T	000.0%R
	080.0%R	117.1%T	037.7%T	045.7%T	014.8%R

127.

76.0

36.5

10.0

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 82

SYSTEM STATUS 22 APR 1993 014:05:26

PMT VOLTAGE	=	3695 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.2 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	46 C	O2 LAMP HOUSING TEMP	=	49 C
GRATING BASE TEMP	=	47 C	ELECT. MODULE TEMP	=	34 C
FILAMENT VOLTAGE	=	5.3 VOLTS	ANODE VOLTAGE	=	236 VOLTS
ANODE CURRENT	=	30 ma			
CHECKSUM	=	21804	DARK READING	=	0

NM	S1	S2	S3	S4	S5
121.00	072.4%R	043.1%T	033.3%T	041.3%T	005.7%R
125.00	071.1%R	052.8%T	043.6%T	050.7%T	011.9%R
130.00	078.4%R	061.3%T	047.7%T	056.8%T	013.9%R
144.00	068.4%R	075.3%T	072.6%T	076.7%T	019.1%R
150.00	065.9%R	063.9%T	069.0%T	073.1%T	000.0%R *
161.00	066.3%R	073.1%T	070.9%T	074.3%T	014.5%R
170.00	060.0%R	080.0%T	075.0%T	076.6%T	016.6%R
180.00	077.0%R	081.9%T	088.5%T	081.9%T	016.3%R
190.00	069.8%R	087.3%T	076.1%T	080.9%T	015.8%R
210.00	089.0%R	085.4%T	081.8%T	092.7%T	030.9%R
	71.6 -2.7		65.9 +2.4		16.3 +4.1

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 83

SYSTEM STATUS 22 APR 1993 01:01:59

FMT VOLTAGE	=	3699 VOLTS	FMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.2 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	45 C	D2 LAMP HOUSING TEMP	=	44 C
GRATING BASE TEMP	=	46 C	ELECT. MODULE TEMP	=	29 C
FILAMENT VOLTAGE	=	5.3 VOLTS	ANODE VOLTAGE	=	290 VOLTS
ANODE CURRENT	=	56 ma			
CHECKSUM	=	19934	DARK READING	=	0

NM	S1	S2	S3	S4	S5
121.60	076.8%R	044.4%T	034.2%T	042.3%T	007.0%R
125.00	078.5%R	025.7%T	051.8%T	064.3%T	004.0%R
130.00	042.6%R	073.5%T	068.6%T	075.9%T	012.7%R
144.00	073.6%R	067.2%T	066.8%T	071.3%T	013.6%R
150.00	067.7%R	066.1%T	068.1%T	073.2%T	011.0%R
161.00	093.2%R	088.3%T	089.3%T	087.8%T	014.2%R
170.00	058.4%R	080.3%T	098.9%T*	110.9%T*	017.4%R
180.00	090.7%R	078.2%T	082.8%T	089.5%T	015.4%R
190.00	055.3%R	060.2%T	056.7%T	057.4%T	015.6%R
210.00	083.5%R	088.2%T	081.1%T	085.8%T	023.5%R
	71.0 -35		66.6 -9.1		13.4 +1.2

ORIGINAL PAGE IS
OF POOR QUALITY

Record # 84

SYSTEM STATUS 22 APR 1993 017:23:09

PMT VOLTAGE	=	3696 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.2 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	45 C	D2 LAMP HOUSING TEMP	=	46 C
GRATING BASE TEMP	=	45 C	ELECT. MODULE TEMP	=	29 C
FILAMENT VOLTAGE	=	5.4 VOLTS	ANODE VOLTAGE	=	298 VOLTS
ANODE CURRENT	=	30 ma			
CHECKSUM	=	14518	DARK READING	=	1

NM	S1	S2	S3	S4	S5
121.60	073.0%R	045.0%T	034.8%T	044.6%T	009.8%R
125.00	074.8%R	053.2%T	042.5%T	052.6%T	000.0%R *
130.00	072.0%R	056.7%T	051.3%T	054.0%T	000.0%R *
144.00	078.1%R	064.5%T	068.7%T	063.5%T	010.4%R
150.00	072.5%R	068.1%T	063.7%T	073.4%T	012.3%R
161.00	069.6%R	076.7%T	069.2%T	075.2%T	013.8%R
170.00	071.2%R	084.9%T	075.3%T	076.7%T	023.2%R
180.00	080.5%R	080.5%T	077.9%T	080.5%T	022.0%R
190.00	073.4%R	075.9%T	070.8%T	079.7%T	021.5%R
210.00	078.6%R	070.6%T	080.0%T	078.6%T	000.0%R *

77.4 -0.1

63.4 -4.1

16.1 -3.1

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Record # 85

SYSTEM STATUS 22 APR 1993 017:59:19

PMT VOLTAGE	=	3695 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.2 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	48 C	O2 LAMP HOUSING TEMP	=	49 C
GRATING BASE TEMP	=	48 C	ELECT. MODULE TEMP	=	31 C
FILAMENT VOLTAGE	=	5.4 VOLTS	ANODE VOLTAGE	=	290 VOLTS
ANODE CURRENT	=	36 ma			
CHECKSUM	=	48449	DARK READING	=	1

NM	S1	S2	S3	S4	S5
121.00	080.9%R	036.9%T	028.7%T	026.9%T	006.6%R
125.00	073.3%R	051.4%T	043.1%T	052.6%T	000.2%R
130.00	076.4%R	050.0%T	050.0%T	056.6%T	009.4%R
144.00	069.5%R	060.0%T	053.3%T	059.0%T	013.3%R
150.00	067.9%R	070.1%T	059.7%T	066.4%T	020.8%R
161.00	252.8%R*	063.8%T	062.5%T	063.5%T	012.8%R
170.00	069.0%R	069.0%T	074.6%T	080.2%T	014.0%R
180.00	061.6%R	072.6%T	076.7%T	073.9%T	015.6%R
190.00	020.0%R*	021.6%T	024.8%T*	024.3%T	005.6%R
210.00	004.6%R	026.1%T	075.3%T	092.3%T	003.8%R
	72.9 -1.6		58.2 -0.3		17.8 -1.6

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Record # 86

SYSTEM STATUS 22 APR 1993 018:44:53

PMT VOLTAGE	=	3692 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.2 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	46 C	O2 LAMP HOUSING TEMP	=	30 C
GRATING BASE TEMP	=	46 C	ELECT. MODULE TEMP	=	32 C
FILAMENT VOLTAGE	=	5.4 VOLTS	ANODE VOLTAGE	=	286 VOLTS
ANODE CURRENT	=	46 ma			
CHECKSUM	=	39163	DARK READING	=	0

NM	S1	S2	S3	S4	S5
121.60	082.5%R	035.8%T	023.3%T	026.9%T	010.5%R
125.00	067.7%R	040.9%T	036.0%T	044.8%T	009.2%R
130.00	073.5%R	056.1%T	047.1%T	058.6%T	016.5%R
144.00	082.8%R	065.6%T	064.6%T	072.7%T	017.1%R
150.00	069.4%R	076.2%T	058.4%T	073.7%T	008.4%R
161.00	037.1%R	039.6%T	069.1%T	034.0%T	005.7%R
170.00	075.8%R	079.0%T	075.8%T	082.2%T	022.5%R
190.00	080.3%R	088.5%T	086.8%T	078.6%T	045.9%R
190.00	072.3%R	080.0%T	073.8%T	087.6%T	000.0%R
210.00	080.6%R	074.1%T	079.0%T	093.5%T	022.5%R

61.0 -25

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Record # 87

SYSTEM STATUS 22 APR 1993 010:59:06

PMT VOLTAGE	=	3692 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+28 SUPPLY VOLTAGE	=	27.2 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	49 C	02 LAMP HOUSING TEMP	=	50 C
GRATING BASE TEMP	=	49 C	ELECT. MODULE TEMP	=	32 C
FILAMENT VOLTAGE	=	5.3 VOLTS	ANODE VOLTAGE	=	294 VOLTS
ANODE CURRENT	=	32 ma			
CHECKSUM	=	24298	DARK READING	=	0

NM	S1	S2	S3	S4	S5
121.60	073.0%R	044.5%T	033.1%T	044.0%T	009.4%R
125.00	076.4%R	048.2%T	038.2%T	048.2%T	014.1%R
130.00	075.7%R	057.0%T	049.5%T	053.2%T	000.0%R
144.00	070.2%R	061.7%T	058.5%T	070.2%T	010.6%R
150.00	073.2%R	068.7%T	058.9%T	065.1%T	000.0%R
161.00	073.0%R	217.4%T	154.3%T	078.8%T	010.7%R
170.00	080.3%R	086.8%T	081.9%T	080.3%T	000.0%R
180.00	087.0%R	085.4%T	087.0%T	080.6%T	022.5%R
190.00	078.5%R	070.0%T	080.0%T	081.4%T	024.2%R
210.00	078.4%R	075.3%T	080.0%T	080.0%T	015.3%R

62.6 +/-1

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POST-TEST

Record # 456

SYSTEM STATUS 27 APR 1993 014:37:25

PMT VOLTAGE	=	3712 VOLTS	PMT SUPPLY VOLTAGE	=	28.3 VOLTS
+25 SUPPLY VOLTAGE	=	27.0 VOLTS	+5 SUPPLY VOLTAGE	=	5.0 VOLTS
+12 SUPPLY VOLTAGE	=	12.0 VOLTS	-12 SUPPLY VOLTAGE	=	12.0 VOLTS
SAMPLE HOUSING TEMP	=	24 C	D2 LAMP HOUSING TEMP	=	24 C
GRATING BASE TEMP	=	23 C	ELECT. MODULE TEMP	=	23 C
FILAMENT VOLTAGE	=	5.3 VOLTS	ANODE VOLTAGE	=	290 VOLTS
ANODE CURRENT	=	22 ma			
CHECKSUM = 36402		DARK READING = 0			

NM	S1	S2	S3	S4	S5
210.00	070.8%R	080.5%T	065.2%T	080.5%T	000.0%R
	056.4%R	051.6%T	106.4%T	091.9%T	022.5%R
	093.5%R	074.0%T	085.7%T	097.4%T	000.0%R
	070.7%R	089.0%T	069.5%T	087.8%T	017.0%R
	113.2%R	092.4%T	116.9%T	107.5%T	026.4%R
	062.5%R	073.6%T	073.6%T	080.5%T	019.4%R
	086.7%R	082.2%T	075.8%T	079.0%T	022.5%R
	072.6%R	069.8%T	067.1%T	086.3%T	027.3%R
	061.2%R	071.2%T	061.2%T	077.5%T	025.0%R

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